ENGLISH TRANSLATION OF

INTERNATIONAL APPLICATION

AS ORIGINALLY FILED

DESCRIPTION

LAMINATION-TYPE RESISTANCE ELEMENT

Technical Field

The present invention relates to a lamination-type resistance element and more particularly to a lamination-type resistance element in which internal electrodes are disposed inside a laminated sinter so as to enable fine adjustment of a resistance value.

Background Art

To date, resistance elements such as PTC thermistors and NTC thermistors have been used for temperature compensation and temperature detection. Among such resistance elements, there is a lamination-type resistance element that can be mounted on a printed-circuit board, etc. Hereinafter, a plurality of examples of related lamination-type resistance elements is described.

Fig. 7 is a sectional view showing a first related example and the resistance element is an NTC thermistor.

In a lamination-type thermistor 1 shown in Fig. 7, first internal electrodes 4a and 4b and second internal electrodes 5a and 5b are contained inside a laminated sinter 3 in which a plurality of thermistor layers 2 are integrally sintered. External electrodes 7 and 9 are formed on the outer surface and more concretely on both end portions of the laminated sinter 3.

One end portion of the first internal electrode 4a and one end portion of the second internal electrode 5a face each other on the same plane surface with a gap 6a therebetween. The other end portion of the first internal electrode 4a is electrically connected to the external electrode 7 and the other end portion of the second internal electrode 4b is electrically connected to the external electrode 8.

Furthermore, one end portion of the first internal electrode 4b

and one end portion of the second internal electrode 5b face each other on the same plane surface with a gap 6b therebetween. The other end portion of the first internal electrode 4b is electrically connected to the external electrode 7 and the other end portion of the second internal electrode 5b is electrically connected to the external electrode 8.

The gaps 6a and the gaps 6b are alternately disposed along the lamination direction of the plurality of thermistor layers 2 inside the laminated sinter 3. Furthermore, the gaps 6a and the gaps 6b are formed at different locations in the direction substantially perpendicular to the lamination direction of the laminated sinter 3.

Fig. 8 is a sectional view showing a second related example and, in the same way as in Fig. 7, the resistance element is an NTC thermistor.

In a lamination-type NTC thermistor 11 shown in Fig. 8, first internal electrodes 14a and second internal electrodes 14b are contained inside a laminated sinter 13 in which a plurality of thermistor layers 12 are integrally sintered. Furthermore, internal electrodes 16 are formed so as to face the first internal electrodes 14a and second internal electrodes 14b through a thermistor layer 12. External electrodes 17 and 18 are formed on the outer surface of the laminated sinter 12 and more concretely on both end portions.

One end portion of the first internal electrode 14a and one end portion of the second internal electrode 14b are formed so as to face each other on the same plane with a gap 15 therebetween. The other end portion of the first internal electrode 14a is electrically connected to the external electrode 17 and the other end portion of the second internal electrode 14b is electrically connected to the external electrode 18.

The internal electrode 16 is a no-connection-type internal electrode both end portions of which are not led out to the outer

surface of the laminated sinter 13 and which is not connected to the external electrodes 17 and 18.

The resistance value of the first related lamination-type resistance element is determined by the size of the gap 6a formed by the first internal electrode 4a and the second internal electrode 5a, the size of the gap 6b formed by the first internal electrode 4b and the second internal electrode 5b, and the overlapping area between the first internal electrode 4a and the second internal electrode 5b and the space therebetween.

Furthermore, the resistance value of the second related lamination-type resistance element is determined by the size of the gap 15 formed by the first internal electrode 14a and the second internal electrode 14b, the overlapping area between the first internal electrode 14a and the no-connection-type internal electrode 16 and the space therebetween, and the overlapping area between the second internal electrode 14b and the no-connection-type internal electrode 16 and the space therebetween.

In the following Patent Document 3, a third related lamination-type resonance element is disclosed. In a resistance element disclosed in Patent Document 3, inside a negative-characteristic thermistor element, first and second internal electrodes are disposed so as to lie on top of one another with a thermistor element layer therebetween, the internal electrode is led out to one end of the negative-characteristic thermistor element, and the other internal electrode is led out to the other end. Then, the first and second external electrodes are formed at both ends of the thermistor element. Furthermore, a resistor layer formed of a resistive material different from the material constituting the thermistor element is laminated on the thermistor element. Then, a pair of internal electrodes one end of each facing one end of the other with a gap therebetween on the same plane are formed inside the resistor layer. One of the internal

electrodes is electrically connected to the first external electrode and the other is electrically connected to the second external electrode.

Here, the resistance value can be set by adjustment of not only material characteristics and the shape of the above-described resister layer, but also the pattern of a pair of electrodes inside the resonator layer, and thus, the freedom of setting the resistance value can be increased.

Furthermore, in the following Patent Document 4, an NTC thermistor as a lamination-type resistance element of a fourth example is disclosed. That is, an NTC thermistor in which a plurality of pairs of internal electrodes, the inner end of one of the pair facing the inner end of the other with a gap therebetween on the same plane, are contained inside a lamination-type resistor. Here, in each pair of internal electrodes, one internal electrode is electrically connected to a first external electrode contained on one end face of the resistor and the other internal electrode is electrically connected to a second external electrode formed on the other end face of the resistor. Then, when seen from a direction perpendicular to the upper face of the resistor, in each of the plurality of pairs, the one internal electrode and the other internal electrode are disposed so as not to lie on top of one another. In this NTC thermistor, since the resistance value is determined by the size of a gap between a pair of internal electrodes disposed on the same plane, it is possible to reduce variations of the resistance value.

Patent Document 1: Japanese Unexamined Patent Application Publication No. 05-243007

Patent Document 2: Japanese Unexamined Patent Application Publication No. 10-247601

Patent Document 3: Japanese Unexamined Patent Application Publication No. 2000-124008

Patent Document 4: Japanese Unexamined Utility Model Registration Application Publication No. 6-34201

Disclosure of Invention

When the resistance value is adjusted in the first and second lamination-type resistance elements, the number of laminations of each internal electrode is increased or reduced. However, in the case of adjustment of the resistance value, in the first related example, since the number of internal electrodes 4a, 4b, 5a, and 5b facing each other through a thermistor layer 2 is increased or reduced, the range of change of the resistance value is wide and fine adjustment of the resistance value is difficult. In the second related example, the number of units formed of internal electrodes 14a and 14b and internal electrodes 16 facing each other through a thermistor 12 is increased or decreased. Accordingly, the range of change of the resistance value is also wide and fine adjustment of the resistance value is difficult.

On the other hand, in the lamination-type resistance element of the third related example, since the resistor layer is formed using a material different from a negative-characteristic thermistor element, the manufacturing process becomes complicated and, as a matter of course, the cost increases. Furthermore, since the thickness of the resistor layer is required to be sufficiently smaller than the thickness of the thermistor element, the design of the resistor and the internal electrodes are naturally restricted. Therefore, reduction in the resistance and fine adjustment of the resistance value are difficult.

Furthermore, in an NTC thermistor described in the above-described Patent Document 4, although variations of the resistance value can be reduced, reduction in the resistance is limited. When the size of the gap is reduced for each pair of internal electrodes disposed with a

gap therebetween on the same plane, it is possible to decrease the resistance value. However, when the gap is reduced, since a short circuit becomes likely to occur, reduction in the resistance is limited.

In consideration of the above problems of the related technology, it is an object of the present invention to provide a lamination-type resistance element having a structure in which fine adjustment of the resistance value can be made in the lamination-type resistance element using a laminated sinter having internal electrodes.

According to a broad aspect of the present invention, it is possible to provide a lamination-type resistance element comprising a laminated sinter having a plurality of ceramic resistance layers and a plurality of internal electrodes laminated therein; and a first external electrode and a second external electrode formed on the outer surface of the laminated sinter. In the lamination-type resistance element, the plurality of internal electrodes contains a plurality of internal electrodes of a first group and a plurality of internal electrodes of a second group, the plurality of internal electrodes of the first group containing a resistance unit in which at least two internal electrodes are disposed so as to face each other through the ceramic resistance layer, one end of the resistance unit being electrically connected to the first external electrode, and the other end being electrically connected to the second external electrode, and the internal electrodes of the second group containing a plurality of pairs of internal electrodes one end of each facing one end of the other with a gap therebetween on the same plane inside the laminated sinter, one internal electrode in each pair being electrically connected to the first external electrode, and the other being electrically connected to the second external electrode.

In a specific aspect of a lamination-type resistance element according to the present invention, the plurality of gaps of the

second group is formed so as to lie on top of one another in the lamination direction in the laminated sinter.

In another specific aspect of a lamination-type resistance element according to the present invention, each of the internal electrodes of the first group contains a first divided internal electrode electrically connected to the first external electrode and a second divided internal electrode electrically connected to the second external electrode and one end of the first divided internal electrode and one end of the second divided internal electrode face each other with a gap therebetween on the same plane, and, regarding the internal electrodes of each pair of the second internal electrode group, when the internal electrode electrically connected to the first external electrode is made a third internal electrode and the other internal electrode electrically connected to the second external electrode is made a fourth internal electrode, the gap which is the closest to the second group among the gaps of the first group is the gap which is the closest to the first group among the gaps between the third and fourth internal electrodes of the second group that are disposed so as to lie on top of one another in the lamination direction.

The structure of the above-described internal electrodes of the first group can be variously modified in the present invention.

That is, in another specific aspect of the present invention, a plurality of pairs of first and second divided internal electrodes are laminated and the gaps between neighboring pairs of electrodes in the lamination direction are formed at different locations when seen from one side in the lamination direction.

Furthermore, in another specific aspect of a lamination-type resistance element according to the present invention, in the internal electrodes of the first group, a no-connection-type internal electrode disposed on top of the first and second divided internal electrodes through a ceramic resistance layer is further contained.

In another specific aspect of a lamination-type resistance element according to the present invention, the internal electrodes of a first group contains the first internal electrode electrically connected to the first external electrode and a second internal electrode electrically connected to the second external electrode, and the first and second internal electrodes are disposed so as to lie on top of one another through a ceramic layer therebetween.

The above-described three lamination-type resistance elements in which the structures of the first internal electrodes are different from each other can be described as the following first to third means.

A lamination-type resistance element as a first means of the present invention comprises a laminated sinter having a plurality of ceramic resistance layers and a plurality of internal electrodes laminated therein; and a first external electrode and a second external electrode formed on the outer surface of the laminated sinter. In the lamination-type resistance element, the internal electrodes contain internal electrodes of a first group and internal electrodes of a second group, wherein the internal electrodes of a first group each contain a first internal electrode and a second internal electrode one end of each being formed so as to face one end of the other with a gap therebetween on the same plane inside the laminated sinter and the other ends being connected to the first external electrode and the second external electrode, respectively, and neighboring gaps between the first and second internal electrodes in the lamination direction of the laminated sinter are formed at different locations when seen from the lamination direction of the laminated sinter, and the internal electrodes of the second group contain a pair of a third internal electrode and a fourth internal electrode one end of each facing one end of the other with a gap therebetween on the same plane inside the laminated sinter and the other ends being connected to the first external electrode and the

second external electrode, respectively, and the gaps formed by the third internal electrodes and fourth internal electrodes are at the same location along the lamination direction of the laminated sinter.

Furthermore, a second means for solving the problems is a lamination-type resistance element comprising a laminated sinter having a plurality of ceramic resistance layers and a plurality of internal electrodes laminated therein; and a first external electrode and a second external electrode formed on the outer surface of the laminated sinter. In the lamination-type resistance element, the internal electrodes contain internal electrodes of a first group and internal electrodes of a second group, wherein the internal electrodes of the first group each contain a first internal electrode and a second internal electrode one end of each being formed so as to face one end of the other with a gap therebetween on the same plane inside the laminated sinter and the other ends being connected to the first external electrode and the second external electrode, respectively, and a no-connection-type internal electrode which is formed so as to lie on top of the first internal electrode and the second internal electrode through the ceramic resistance layer in the lamination direction of the laminated sinter and which is not connected to the first and second external electrodes, and the internal electrodes of the second group each contain a third internal electrode and a fourth internal electrode one end of each facing one end of the other with a gap therebetween on the same plane inside the laminated sinter and the other ends being connected to the first external electrode and the second external electrode, respectively, and the gaps formed by the third internal electrodes and fourth internal electrodes are at the same location along the lamination direction of the laminated sinter.

A third means is a lamination-type resistance element comprising a laminated sinter having a plurality of ceramic resistance layers and a plurality of internal electrodes laminated therein; and a first

external electrode and a second external electrode formed on the outer surface of the laminated sinter. In the lamination-type resistance element, the internal electrodes contain internal electrodes of a first group and internal electrodes of a second group, the internal electrodes of the first group each contain a first internal electrode connected to the first external electrode and a second internal electrode connected to the second external electrode which face each other through the ceramic resistance layer, and the internal electrodes of the second group each contain a third internal electrode and a fourth internal electrode one end of each facing one end of the other with a gap therebetween on the same plane inside the laminated sinter and the other ends being connected to the first external electrode and the second external electrode, respectively, and the gaps formed by the third internal electrodes and fourth internal electrodes are at the same location along the lamination direction of the laminate sinter.

In a lamination-type resistance element of the present invention, fine adjustment of the resistance value can be made by forming internal electrodes of a second group inside a laminated sinter. That is, in a plurality of pairs of internal electrodes constituting the internal electrodes of the second group, the internal electrodes of each pair are disposed with a gap therebetween on the same plane inside the laminated sinter. Since the resistance value determined by the gap is small, fine adjustment of the resistance value of the lamination-type resistance element can be made by changing the size of the gap in the plurality of pairs of internal electrodes and the number of pairs in the plurality of pairs of electrodes. That is, fine adjustment of the resistance value can be made by adjustment of the portion where the internal electrodes of the second group are constituted without greatly affected the resistance value to be determined by the portion where the internal electrodes of the first

group are constituted.

Furthermore, since it is possible to design a laminated sinter, that is, to design and set the resistance value in the same process as the technology for laminating ceramic resistance layers and internal electrodes, fine adjustment of the resistance value can be easily made.

Brief Description of the Drawings

Fig. 1 is a sectional view showing a first embodiment of a lamination-type resistance element of the present invention.

Fig. 2 is a sectional view showing a second embodiment of a lamination-type resistance element of the present invention.

Fig. 3 is a sectional view showing a third embodiment of a lamination-type resistance element of the present invention.

Fig. 4 is a front sectional view showing a modified example of a lamination-type resistance element for describing the process for making fine adjustment of the resistance value by using a lamination-type resistance element of the present invention.

Fig. 5 is a front sectional view of a lamination-type resistance element obtained by increasing the number of laminations of the second group internal electrodes of the lamination-type resistance element shown in Fig. 4.

Fig. 6 is a front sectional view of a lamination-type resistance element obtained by decreasing the number of laminations of the second group internal electrodes of the lamination-type resistance element shown in Fig. 4.

Fig. 7 is a sectional view showing a first example of a related lamination-type resistance element.

Fig. 8 is a sectional view showing a second example of the related lamination-type resistance element.

Reference Numerals

21, 31, and 41 lamination-type resistance elements

23, 33, and 43 laminated sinters

24a, 24b, 34a, and 44 first internal electrodes

25a, 25b, 34b, and 45 second internal electrodes

36 internal electrode (no-connection-type internal electrode)

28, 38, and 48 gaps

29, 30, 39, 40, 49, and 50 external electrodes

51 lamination-type resistance element

Best Mode for Carrying Out the Invention

Embodiment 1

Fig. 1 is a sectional view of a first embodiment of a lamination-type resistance element.

A lamination-type resistance element 21 shown in Fig. 1 contains a laminated sinter 23 in which a plurality of NTC thermistor layers 22 as a plurality of ceramic resistance layers is laminated and integrally sintered. First internal electrodes 24a and 24b and second internal electrodes 25a and 25b are contained inside the laminated sinter 23. External electrodes 29 and 30 are formed on the outer surface, concretely, on both end portions of the laminated sinter 23.

The first internal electrode 24a as a first divided internal electrode and the internal electrode 25a as a second divided internal electrode are formed in such a way that one end portion of the internal electrode 24a and one end portion of the internal electrode 25a face each other on the same plane surface with a gap 26a therebetween. The other end portion of the first internal electrode 24a is electrically connected to the external electrode 29 and the other end portion of the second internal electrode 25a is electrically connected to the external electrode 30.

Moreover, when internal electrodes on the same plane are seen as a unified electrode, the divided internal electrodes indicate one

electrode separated by a gap. For example, the internal electrode 24a and the internal electrode 25a are considered as a unified electrode on the same plane and each of the ones separated by a gap may be called a divided internal electrode 24a and a divided internal electrode 25a, respectively. Furthermore, when the internal electrode 25a and an internal electrode 24b, for example, lie on top of one another through a thermistor layer, the internal electrode 25a may be simply called an internal electrode.

Furthermore, the first internal electrode 24b as a divided internal electrode and the second internal electrode 25b are formed in such a way that one end portion of the internal electrode 24b and one end portion of the internal electrode 25b face each other on the same plane with a gap 26b therebetween. The other end portion of the first internal electrode 24b is electrically connected to the external electrode 29 and the other end portion of the second internal electrode 25b is electrically connected to the external electrode 30.

The gaps 26a and 26b are disposed inside the sinter 23 so as to be next to each other along the lamination direction of the plurality of thermistors 22. Furthermore, the gaps 26a and 26b are formed so as to be at different locations in the direction perpendicular to the lamination direction of the sinter 23 and in the direction in which both end portions of the sinter 23 are connected. The above-described structure of the first internal electrodes 34a and 24b corresponds to a first internal electrode group A of the present invention. Here, a resistance unit in which the two internal electrodes 24b and 24b are each put on top of the internal electrode 25a with a thermistor layer as a ceramic resistance layer therebetween is constituted. One end of the resistance unit is connected to the first external electrode 29 and the other end is connected to the second external electrode 30. Moreover, in the present embodiment, the internal electrodes 24b and 24b and the internal electrode 24a, that is, the three internal

electrodes are put on top of one another with thermistor layers thereamong in the above-described resistant unit of the first internal electrode group A, but, in the present invention, since it is sufficient to have at least two internal electrodes facing each other through a ceramic resistance layer, the number of laminations of internal electrodes facing each other through a ceramic resistance layer is not particularly limited.

The lamination-type thermistor 21 further contains the following structure. That is, a second internal electrode group B is formed above the first internal electrode group A of the inside the sinter 23.

The second internal electrode group B has the following structure. Third internal electrodes 27a and fourth internal electrodes 27b are contained inside the laminated sinter 23 in which the plurality of thermistor layers 22 are integrally sintered. The third internal electrodes 27a and the fourth internal electrodes 27b are formed in such a way that one end portion of the internal electrode 27a and one end portion of the internal electrode 27b face each other on the same plane with a gap 28 therebetween. The other end portion of the third internal electrode 27a is electrically connected to the external electrode 29 and the other end portion of the fourth internal electrode 27b is electrically connected to the external electrode 30.

The gaps 28 of the second internal electrode group B are formed at the same location, when seen from one end side of the lamination direction of the plurality of thermistor layers 22, for example, from the upper, inside the laminated sinter 23. Furthermore, the gaps 28 are formed at a different location from the gap 26a of the first internal electrode group A when seen from one end side in the lamination direction of the thermistor layers, more concretely, at a different location in the direction connecting both end portions of the laminated sinter 23. Moreover, in the second internal electrode group B shown in Fig. 1, three sets of electrodes formed of a third

internal electrode 27a and a fourth internal electrode 27b are put on top of one another, but the number of layers of the combination may be designed according to a target resistance value. Furthermore, in Fig. 1, the thickness of an NTC thermistor layer 22a existing between the first internal electrode group A and the second internal electrode group B is larger than the thickness of the other NTC thermistor layers 22, but the thickness may also be made the same.

In the lamination-type resistance element according to the first embodiment, the resistance value is determined in the following way. That is, in the first internal electrode group A, the resistance value is determined by the size of the gaps 26a and 26b formed between the first internal electrodes 24a and 25a and between the second internal electrodes 24b and 25b, respectively, and by the overlapping area and space between the first internal electrode 24a and the second internal electrode 25b. Moreover, in the second internal electrode group B, the resistance value is determined by the size of the gaps 28 formed between the third internal electrodes 27a and the fourth internal electrodes 27b. Accordingly, the resistance value of the lamination-type resistance element becomes a composite resistance value of the resistance values of the first internal electrode group A and the second internal electrode group B. In the second internal electrode group B, although the resistance value is determined by the size of the gap 28, the resonance value formed by the gap 28 is small.

Furthermore, in the first embodiment, since three sets of an internal electrode 27a and an internal electrode 27b are laminated in the second internal electrode group B, the three gaps 28 are next to each other in the lamination direction of the thermistor layers 22 and disposed so as to lie on top of one another when seen from one end side in the lamination direction. That is, the gaps 28 and 28 face each other through one thermistor layer 22. In this way, since a plurality of gaps 28 is disposed in the second internal electrode

group B and the plurality of gaps are disposed so as to lie on top of one another, not only is the resistance value formed by the size of one gap 28 small, but the resistance value of the second internal electrode group B determined by the space between the plurality of gaps 28 is also small. Accordingly, it becomes possible to make fine adjustment of the resistance value of the whole lamination-type resistance element by means of the second internal electrode group.

Moreover, in the lamination-type thermistor 21 of the first embodiment, not only can fine adjustment of the resistance value be made in the above-described way, but also there is an advantage in that fine adjustment of the resistance value can be made more precisely. That is, in the lamination-type thermistor 21 of the first embodiment, the gap 26b between a first internal electrode 24b and a second internal electrode 25b of the first internal electrode group and the gap 28 between a third internal electrode 27a and a fourth internal electrode 27b of the second internal electrode group are disposed so as to be at the same location, that is, to lie on top of one another when seen from the lamination direction, the gap 26b and the gap 28 being next to each other through the thermistor layer 22a. In order to show this more clearly, in Fig. 1, reference characters X and Y are given to the gaps which can be made close to each other at the same location when seen from the above-described lamination direction.

As is clear in Fig. 1, the gap X, the closest to the second internal electrode group, in the gaps 26a in the first internal electrode group and the gap Y, the closest to the first internal electrode group, in the gaps 28 in the second internal electrode group are formed at the same location when seen from the lamination direction.

This means that the first internal electrode 24b and the second internal electrode 25b for constituting the gap X can be made in the

same shape as the third internal electrode 27a and the fourth internal electrode 27b for constituting the gap Y. In the present embodiment, since the internal electrode pattern on the upper surface of the thermistor layers 22 is the same as the internal electrode pattern on the lower surface and the gaps X and Y are at the same location when seen from one end side in the lamination direction, fine adjustment of the resistance value can be made more precisely. This is because the inner ends of the internal electrodes 24b and 25b constituting the gap X in the first internal electrode group and the inner ends of the third and fourth internal electrodes 27a and 27b constituting the gap Y in the second internal electrode group are uniform in location and accordingly the current path becomes uniform and variations of the resistance value can be more reduced.

Accordingly, preferably, when the first internal electrode group and the second internal electrode group are disposed in parallel in the lamination direction and the above-described gaps are contained in the internal electrodes close to each other in the first internal electrode group and the second internal electrode group, it is desirable to dispose the gaps at the same location when seen from the lamination direction, that is, to dispose the gaps so as to lie on top of one another.

However, in the present invention, it is not necessarily required to put the second internal electrode group above or below the first internal electrode group in parallel, and the first internal electrode group may be disposed in the portion where the second internal electrode group is contained.

Embodiment 2

Fig. 2 is a sectional view of a second embodiment of the lamination-type resistance element.

A lamination-type resistance element 31 contains a laminated sinter 33 in which a plurality of NTC thermistor layers 32 is

laminated and integrally sintered. First internal electrodes 34a and second internal electrodes 34b are contained in the laminated sinter 33. Furthermore, an internal electrode 36 is formed so as to face the first internal electrodes 34a and the second internal electrodes 34b through a thermistor layer 32. External electrodes 39 and 40 are formed on the external surface of the laminated sinter 32, concretely, at both end portions.

One end portion of the first internal electrode 34a as a divided internal electrode and one end portion of the second internal electrode 34b as a divided internal electrode are made to face each other on the same plane with a gap 35 therebetween inside the laminated sinter 33. The other end portion of the first internal electrode 34a is electrically connected to the external electrode 39 and the other end portion of the second internal electrode 34b is electrically connected to the external electrode 40.

The internal electrode 36, in which both end portions are not led to the external surface of the laminated sinter 33, is a no-connection-type internal electrode not electrically connected to the external electrodes 39 and 40. The structure having the first internal electrodes 34a, the second internal electrodes 34b, and the no-connection-type internal electrode 36 corresponds to first internal electrode group C of the present invention.

Moreover, in the first internal electrode group C, the first internal electrodes 34a and second internal electrodes 34b and the no-connection-type internal electrode 36 lie on top of one another through a thermistor layer. That is, a resistance unit having the internal electrodes 34a and 34b and the no-connection-type internal electrode 36 is constituted. One end of the resistance unit is connected to the first external electrode 39 and the other end is connected to the second external electrode 40.

Furthermore, also in the present embodiment, it is sufficient to

have at least two internal electrodes disposed so as to lie on top of one another with a thermistor layer therebetween, that is, it is sufficient that the number of ceramic resistance layers sandwiched by internal electrodes is one or more and the number is not restricted in particular.

The lamination-type thermistor 31 further contains the following structure. That is, a second internal electrode group D is formed inside the laminated sinter 33 so as to be close to the first internal electrode group C.

The second internal electrode group D contains the following structure. Third internal electrodes 37a and fourth internal electrodes 37b are contained inside the laminated sinter 33 in which a plurality of thermistor layers 32 are laminated and integrally sintered. One end portion of the third internal electrode 37a and one end portion of the fourth internal electrode 37b face each other on the same plane with a gap 38 therebetween inside the laminated sinter 33. The other end portion of the third electrode 37a is electrically connected to the external electrode 39 and the other end portion of the fourth electrode 37b is electrically connected to the external electrode 40.

The gaps 38 of the second internal electrode group D are formed at the same location along the lamination direction of the plurality of thermistor layers 32 inside the laminated sinter 33. The gaps 38 shown in Fig. 2 are formed so as to be substantially at the same distance from both end portions of the laminated sinter 33, that is, to be located substantially in the middle. Furthermore, the gaps 38 are formed at the same location as the gaps 35 of the first internal electrode group C when seen from the lamination direction of the thermistor layers 32, more concretely, at the same location in the direction of the connection of both end portions of the laminated sinter 33, but the gaps 38 may be formed at different locations.

Furthermore, in the second internal electrode group D shown in Fig. 2, although the third internal electrodes 37a and the fourth internal electrodes 37b are formed in three layers, the number of layers may be designed according to the target resistance value. Furthermore, in Fig. 2, although the thickness of the NTC thermistor layers 32a existing between the first internal electrode group C and the second internal electrode group D is made larger than the thickness of the other NTC thermistor layers 32, the thickness may be made the same.

In the lamination-type resistance element according to the second embodiment, the resistance value is determined in the following way. That is, in the first internal electrode group C, the resistance value is determined by the size of the gap 35 formed by the first internal electrode 34a and the second internal electrode 34b, the overlapping area between the first internal electrode 34a and the no-connection-type internal electrode 36 and the space between the both, and the overlapping area between the second internal electrode 34b and the no-connection-type electrode 36 and the space between the both. Furthermore, in the second internal electrode group D, the resistance value is determined by the size of the gap 38 formed by the third internal electrode 37a and the fourth internal electrode 37b. Accordingly, the resistance value of the lamination-type resistance element becomes a composite resistance value of the resistance values of the first internal electrode group C and the second internal electrode group D. In the second internal electrode group D, although the resistance value is determined by the size of the gap 38, a plurality of gaps 38 is at neighboring locations along the lamination direction of the thermistor layers and formed at the same location, and the resistance value determined by the size of the gap 38 is small. Accordingly, fine adjustment of the resistance value of the whole of the lamination-type resistance element becomes possible by means of the second internal electrode group D.

Embodiment 3

Fig. 3 is a sectional view of a third embodiment of the lamination-type resistance element.

In a lamination-type resistance element 41 shown in Fig. 3, first internal electrodes 44 and second internal electrodes 45 are formed inside a laminated sinter 43 in which a plurality of NTC thermistor layers 42 are laminated and integrally sintered. External electrodes 49 and 50 are formed on the outer surface, concretely, in both end portions of the laminated sinter 43.

The first internal electrode 44 and the second internal electrode 45 are formed so that one end portion of each electrode may extend to one end portion of the laminated sinter 43. The other end portion of the first internal electrode 44 is electrically connected to the external electrode 49 and the other end portion of the second internal electrode 44 is electrically connected to the external electrode 50. The structure formed of the above first internal electrodes 44 and 45 corresponds to the first internal electrode group E of the present invention.

In the present embodiment, in the first internal electrode group E, a plurality of internal electrodes 44 and 45 are disposed so as to lie on top of one another through a thermistor layer as a ceramic resistance layer. A resistance unit having the plurality of internal electrodes 44 and 45 is constituted, and one end of the resistance unit is connected to the external electrode 49 and the other end is connected to the external electrode 50.

Moreover, the number of laminations of the internal electrodes lying on top of one another with a thermistor layer therebetween, which constitutes the above resistance unit, is not limited to four as shown in Fig. 4. That is, it is sufficient that at least two internal electrodes are disposed so as to lie on top of one another with a thermistor layer therebetween. That is, the number of ceramic

resistance layers for taking out the resistance value sandwiched between internal electrodes may be any number of one or more.

The lamination-type thermistor 41 further contains the following structure. That is, a second internal electrode group F is formed next to the first internal electrode group E inside the laminated sinter 43.

The second internal electrode group F has the following structure. Third internal electrodes 47a and fourth internal electrodes 47b are formed inside the laminated sinter 43 in which the plurality of thermistor layers 42 are laminated and integrally sintered. The third internal electrode 47a and the fourth internal electrode 47b are formed in such a way that one end portion of the electrode 47a and one end portion of the electrode 47b face each other on the same plane with a gap 48 therebetween inside the laminated sinter 43. The other end portion of the third internal electrode 47a is electrically connected to the external electrode 49 and the other end portion of the fourth internal electrode 47b is electrically connected to the external electrode 50.

A plurality of gaps 48 of the second internal electrode group F is formed inside the laminated sinter 43 in such a way that the gaps 48 are next to each other along the lamination direction of the plurality of thermistor layers 42 and at the same location when seen from the lamination direction. The gaps 48 shown in Fig. 3 are formed so as to be close to the external electrode 50. Moreover, in the second internal electrode group F shown in Fig. 3, although the third internal electrode 47a and the fourth internal electrode 47b are formed in three layers, it is sufficient that they are formed so as to have at least two layers.

In the lamination-type resistance element according to the third embodiment, the resistance value is determined in the following way. That is, in the first internal electrode group E, the resistance value

is determined by the overlapping area of the first electrode 44 and the second internal electrode 45 and the space between the internal electrodes 44 and 45. Moreover, in the second internal electrode group F, the resistance value is determined by the gap 48 formed by the third internal electrode 47a and the fourth internal electrode 47b. Accordingly, the resistance value of the lamination-type resistance element becomes a composite resistance value of the first internal electrode group E and the second internal electrode group F. In the second internal electrode group F, the resistance value is determined by the size of the gaps 48. The gaps are positioned so as to be next to each other in the lamination direction of the thermistor layers 42 and to be at the same location when seen from the lamination direction. The resistance value given by the size of the plurality of gaps 48 is small. Accordingly, it becomes possible to make fine adjustment of the whole resistance value of the lamination-type resistance element by means of the second internal electrode group F.

Next, it is more concretely described that, when the lamination-type resistance element of the present invention is used, it is possible to make fine adjustment of the resistance value by increasing or decreasing the number of laminated layers of the second internal electrode group.

Fig. 4 is a front sectional view of a lamination-type thermistor 51 according to a modified example of the resistance thermistor 31 of the embodiment shown in Fig. 2. The lamination-type thermistor 51 is the same as the lamination-type thermistor 31 except that the first internal electrode 34a and the second internal electrode 34b in the uppermost layer shown in Fig. 2 are not contained. Accordingly, the same reference numeral is given to the same portion and the description for Fig. 2 is cited.

It is now assumed that a lamination-type thermistor 51 having a resistance value of 47000 Ω in design as shown in Fig. 4 is

manufactured by way of experiment using a specific thermistor material, for example. However, practically there are variations in the thermistor material to be used and the resistance value of the obtained lamination-type thermistor 51 may vary. For example, when the resistivity of the thermistor material is high, the resistance value becomes higher than 47000 Ω. For example, when the resistance value is about 47734 Ω, it is sufficient to increase the number of pairs of internal electrodes by one regarding the second internal electrode group as shown in Fig. 5. In this way, the resistance value can be reduced by about 4.0% by increasing the number of pairs of electrodes formed of the third and fourth internal electrodes of the first internal electrode group by one.

Furthermore, when the resistivity of the thermistor material to be used becomes smaller, the lamination-type thermistor 51 having a resistance value lower than the target resistance value can be obtained. That is, when the lamination-type thermistor 51 shown in Fig. 4 is manufactured by way of experiment and the resistance value becomes about 45825 Ω, it is sufficient to reduce the number of pairs of electrodes formed of the third and fourth internal electrodes 37a and 37b in the first internal electrode group by one to result in two as shown in Fig. 6. In this case, it is possible to increase the resistance value by about 2.5% and, as a result, it is possible to realize the target resistance value of 47000 Ω.

As described above, in the lamination-type resistance element of the present invention, it is understood that fine adjustment of the resistance value can be performed by increasing or decreasing the number of pairs of electrodes formed of the third and fourth internal electrodes in the first internal electrode group. When the number of pairs of electrodes increases, very fine adjustment of the resistance value can be performed such a change in the resistance value of about 0.5%, for example. Accordingly, it is understood that very fine

adjustment of the resistance value over a wide range can be performed by changing the number of laminations of electrodes.

In each lamination-type resistance element in the above-described embodiments 1, 2, and 3, an example of an NTC thermistor is shown, but the lamination-type resistance element can be applied to PTC thermistors.